Citation:

Berkey CS, Rockett HRH, Field AE, Gillman MW, Colditz GA. Sugar-added beverages and adolescent weight change. *Obes Res.* 2004;12:778-788.

PubMed ID: 15166298

Study Design:

Cohort study (longitudinal, prospective)

Class:

B - Click here for explanation of classification scheme.

Research Design and Implementation Rating:

NEUTRAL: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

To evaluate the relationship between BMI changes and intake of sugar-added beverages, milk, fruit juices and diet soda.

Inclusion Criteria:

Children of nurses in the Nurses' Health Study II.

Exclusion Criteria:

- Reported height of more than three SD above gender- and age-specific mean and any one-year height change more than one in decrease or more than three SD increase above mean change (1.65% excluded)
- BMI below 12.0kg/m^2, more than three SD above or below age- and gender-specific mean (0.87% excluded)
- Less than 500 or more than 5,000 total kcal per day (0.53% excluded).

Description of Study Protocol:

- *Recruitment:* Baseline questionnaires sent by mail in 1996 to Growing Up Today Study (GUTS) participants (nine- to 14-year-old offspring of Nurses' Health Study II participants) and again in 1997 and 1998.
- *Statistical analysis:* Models include all beverages simultaneously.
- *Test for bias:* Small differences in age, BMI, individual beverage intake and total energy intake between baseline values for those who did vs. those who did not do follow-up (see comments)
- *Cross-sectional:* Linear regression models
- *Longitudinal:* Mixed linear regression models; beverage intake over year corresponding to

each annual BMI change.

Data Collection Summary:

Timing of Measurements

- Questionnaires sent by mail in 1996, 1997 and 1998.

Dependent Variables

- BMI (self-reported height and weight)
    1. Annual change in BMI
    2. *Categories using earlier BMI:* "Overweight" (>85th percentile); "normal weight" (10th to 85th percentile); "very lean" (<10th percentile).

Independent Variables

- Diet (semi-quantitative 132-item FFQ over the past year; valid and reproducible in comparison to 24-hour recall)
    1. *Sugar-added:* Soda, sweetened iced tea, non-carbonated fruit drinks
    2. *Fruit juices:* Orange, apple, other
    3. Diet soda
    4. *Milk:* In glass or on cereal, including chocolate
    5. *Alcohol and coffee:* Low, so no analysis included.
- *Physical activity:* Questionnaire; hours per day within each season over the past year in 17 activities and team sports outside gym class; excluded from physical activity analysis if more than 40 hours per week (3.8%)
- *Inactivity:* Questionnaire; hours per day of TV, videos or VCR, Nintendo, Sega, computer games [excluded from inactivity analysis if more than 80 hours per week (0.94%)]
- *Age:* From birthdate
- *Race and ethnicity:* Six categories
- *Tanner stage:* Self-report using illustrations of pubic hair and stage of menarche.

Control Variables

- Prior-year intakes
- Total energy intake
- Gender (separate models).

Description of Actual Data Sample:

- *Initial N:* 16,771
- *Attrition (final N):* 6,871 females, 5,321 males
- *Age:* Nine to 14 years old at baseline
- *Ethnicity:* 94.7% white
- *Location:* 50 US states.

Summary of Results:

Cross-Sectional Analysis at Baseline

- Higher BMI related to increased sugar-added beverages (+0.06kg/m^2 per serving; P=0.04)
- Lower BMI related to increased milk, decreased diet soda
- Higher energy intake related to increased milk, increased fruit juice and increased sugar-added beverages.

Longitudinal Analysis

- Beverage intake as a continuous variable during one year of BMI change
  - *Males:* Increased BMI related to increased milk (P=0.056), increased sugar-added beverages (P=0.038), increased diet soda (P=0.016) and increased fruit juice (P=0.056). All but diet soda (P=0.017) NS after adjusting for energy intake, which became insignificant after controlling for prior-year beverage intake.
  - *Regarding diet soda intake:* The researchers reported that overweight boys drank three times the amount of diet soda than non-overweight boys, but did not substitute diet soda for regular soda. So overweight boys drank the same amount of sugar-sweetened soda, but drank more diet soda (which had no relationship to total caloric intake).
  - *Females:* Higher BMI not significantly related to any beverages, with or without controlling for energy intake.
- Sugar-added beverage intake as a categorical variable
  - (Zero, one, two, three or more servings per day) to permit non-linear trends (not adjusted for energy intake)
  - *Males:* Dose-response trend confirmed
  - *Females:* Compared to non-drinkers (zero to half of one serving per day), higher BMI for 1.0 to 1.5 servings per day (+0.068kg/m^2, P=0.02), two servings per day (+0.09kg/m^2, P=0.06) or three servings per day (+0.08kg/m^2, P=0.06).
- Beverage change from prior year
  - *Males:* Increased sugar-added beverage intake was related to higher BMI (P=0.01) when unadjusted for energy intake. When adjusted for prior-year or change in energy intake, NS vs. no change in intake, increased more than one serving per day from previous year gained more BMI (+0.10kg/m^2, P=0.02), increased more than two servings per day gained even more BMI (+0.14kg/m^2, P=0.01).
  - All beverages related to +0.03kg/m^2 per serving (P<0.01); NS when adjusted for energy intake
  - *Females:* Increased sugar-added beverage related to higher BMI (P=0.08) when unadjusted for energy intake; when adjusted for prior year or change in energy intake, diminished effect vs. no change in intake, increased more than one serving per day from previous year NS with BMI (+0.07kg/m^2, P=0.08), increased more than two servings per day gained BMI (+0.10kg/m^2, P=0.05).
  - All beverages NS related to BMI with or without adjusting for energy intake.

Author Conclusion:

- Consumption of sugar-added beverages may contribute to weight gain among adolescents, probably due to their contribution to total energy intake, because adjustment for calories greatly attenuated the estimated associations.
- Our strongest and most consistent evidence was a linear association between sugar-added beverage intakes (past year and change from prior year) and weight gain in boys (both P<0.05). The evidence for girls was less compelling, but still suggestive (P<0.10) of a linear association between sugar-added beverages and weight gain. Girls who drank one serving

per day during the past year gain more weight than non-drinkers (P<0.05). Both boys and girls who increased their intakes by two or more servings per day from the previous year experienced significant weight gain, as did boys who increased their intakes by one serving per day from the previous year. However, the magnitudes of these estimated effects were small: A boy consuming three servings of sugar-added beverages over 10 years is expected to gain only 0.9BMI more than if he consumes none.

Reviewer Comments:

Strengths

- *Longitudinal analysis*
- *Included all beverages, so minimal confounding of other beverages.*

Limitations

- *Portion size for soda not specified on FFQ (can or glass) + FFQ is semi-quantitative*
- *Self-reported height and weight*
- *Mostly white participants*
- *Those lost to attrition reported higher sugar-added beverage intake and lower milk intake at baseline than those who stayed in the study, which may have biased results; also slightly older at baseline*
- *Not all potential confounding variables examined or included in multivariate models.*

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions		
1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies)	N/A
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice?	Yes
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	N/A

Validity Questions		
1.	**Was the research question clearly stated?**	Yes
1.1.	Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified?	Yes
1.2.	Was (were) the outcome(s) [dependent variable(s)] clearly indicated?	Yes

1.3.	Were the target population and setting specified?	Yes
2.	**Was the selection of study subjects/patients free from bias?**	Yes
2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	Yes
2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes
2.4.	Were the subjects/patients a representative sample of the relevant population?	No
3.	**Were study groups comparable?**	Yes
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	N/A
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	N/A
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	Yes
3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	Yes
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	**Was method of handling withdrawals described?**	Yes
4.1.	Were follow-up methods described and the same for all groups?	Yes
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	Yes
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	Yes
4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A

5.	**Was blinding used to prevent introduction of bias?**	No
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	N/A
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	No
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	No
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	**Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?**	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	N/A
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	N/A
6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	N/A
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	N/A
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	N/A
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	**Were outcomes clearly defined and the measurements valid and reliable?**	No
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	No
7.5.	Was the measurement of effect at an appropriate level of precision?	No

	7.6.	Were other factors accounted for (measured) that could affect outcomes?	Yes
	7.7.	Were the measurements conducted consistently across groups?	Yes
8.	**Was the statistical analysis appropriate for the study design and type of outcome indicators?**		Yes
	8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes
	8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
	8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
	8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	N/A
	8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	Yes
	8.6.	Was clinical significance as well as statistical significance reported?	Yes
	8.7.	If negative findings, was a power calculation reported to address type 2 error?	N/A
9.	**Are conclusions supported by results with biases and limitations taken into consideration?**		Yes
	9.1.	Is there a discussion of findings?	Yes
	9.2.	Are biases and study limitations identified and discussed?	Yes
10.	**Is bias due to study's funding or sponsorship unlikely?**		Yes
	10.1.	Were sources of funding and investigators' affiliations described?	Yes
	10.2.	Was the study free from apparent conflict of interest?	Yes